Responding to Climate Change in the Chesapeake Bay Watershed

A draft report fulfilling Section 202(d) of Executive Order 13508

November 19, 2009

The charge from Executive Order 13508:
Sec. 202 -- Reports on Key Challenges to Protecting and Restoring the Chesapeake Bay. Within 120 days from the date of this order, the agencies identified in this section as the lead agencies shall prepare and submit draft reports to the Committee making recommendations for accomplishing the following steps to protect and restore the Chesapeake Bay:

> (d) assess the impacts of a changing climate on the Chesapeake Bay and develop a strategy for adapting natural resource programs and public infrastructure to the impacts of a changing climate on water quality and living resources of the Chesapeake Bay watershed;

PART 6—PROTECT CHESAPEAKE BAY AS THE CLIMATE CHANGES

> *Sec. 601.* The Secretaries of Commerce and the Interior shall, to the extent permitted by law, organize and conduct research and scientific assessments to support development of the strategy to adapt to climate change impacts on the Chesapeake Bay watershed as required in section 202 of this order and to evaluate the impacts of climate change on the Chesapeake Bay in future years. Such research should include assessment of:
>
> (a) the impacts of sea-level rise on the aquatic ecosystem of the Chesapeake Bay, including nutrient and sediment load contributions from stream banks and shorelines;
>
> (b) the impacts of increasing temperature, acidity, and salinity levels of waters in the Chesapeake Bay;
>
> (c) the impacts of changing rainfall levels and changes in rainfall intensity on water quality and aquatic life;
>
> (d) potential impacts of climate change on fish, wildlife, and their habitats in the Chesapeake Bay and its watershed; and
>
> (e) potential impacts of more severe storms on Chesapeake Bay resources.

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Disclaimer:
This draft document is the Department of Commerce's (DOC) and Department of the Interior's (DOI) current draft report under Section 202d of Executive Order 13508 (EO) making recommendations to the Federal Leadership Committee (FLC) for an adaptation strategy in response to climate change impacts in the Chesapeake Bay watershed. DOC and DOI intend to release this draft document to the public concurrently with its submission to the FLC. After the FLC has considered this draft, along with the other draft reports prepared pursuant to the EO, it will prepare a draft strategy to restore the Bay and publish it in the Federal Register for public comment. The current draft report includes preliminary recommendations which may change as the draft strategy is developed. Because this draft document is only intended as input into a strategy for future agency action, it is not a final agency action subject to judicial review. Nor is this draft document a rule. Nothing in this draft document is meant to, or in fact does, affect the substantive or legal rights of third parties or bind DOC or DOI. While this draft document reflects DOC and DOI's current thinking regarding recommendations to protect and restore the Bay, the agencies reserve the discretion to modify the report as it works with the FLC to develop the strategy, or act in a manner different from this report as appropriate.

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I. Executive Summary

Climate change is one of the most significant challenges to successful restoration and protection of the Chesapeake Bay and its watershed. Scientists project that climate change will have a variety of impacts on this region including rising sea levels, warmer water and air temperatures, and stronger storms. These impacts will have significant consequences for the Bay and its 64,000 square mile watershed, as well as 17 million people calling this region their home. The Chesapeake Bay watershed includes six states and the District of Columbia ; and is highly responsive to prevailing weather conditions in the watershed. Changes in climate patterns, superimposed on population growth, land use change, and other environmental management challenges, are likely to affect the region's ability to meet Chesapeake Bay Program restoration and conservation targets. Shifts in key climatic variables may significantly increase the currently projected costs and timelines for achieving water quality and living resource restoration goals. Additionally, the Chesapeake Bay region has some of the highest land subsidence rates along the Eastern Seaboard, creating extremely vulnerable shorelines. Many of the region's urban centers and particularly significant ecosystems are in low-lying areas that are particularly vulnerable to sea-level rise and storm surge. As an example, Hampton Roads, Virginia is one of the nation's population center's most at risk from sea-level rise and storm surge due to the concentration of people living in this vulnerable low-lying area. Most wetlands on Maryland's eastern shore are likely to be inundated under even moderate sea-level rise scenarios. Due to the comprehensive nature of climate change effects federal agencies must take collective action to ensure that these effects are considered in the development of regional restoration goals and conservation strategies.

The federal government should be the leader in develop ing climate change response strategies. Federal agencies own approximately 2.2 million acres within the Chesapeake Bay watershed, represent ing about 5.3% of the total watershed land area. The federal landholdings primarily include Department of Defense facilities, National Wildlife Refuges, National Parks, and National Forest Lands, all of which are vulnerable to climate changes. Additional landholdings, owned by state and private organizations are supported with federal funding. All federal landholders and non-federal landholders receiving federal support should implement climate change response plans to minimize impacts on their resources in light of projected changes. This report focuses on how federal agencies can and should respond to these impacts and provide guidance and support to stakeholders as they develop similar adaptation strategies.

This report responds to Section 202d of Executive Order 13508 (EO) which charges Federal agencies to make recommendations to "...assess the impacts of a changing climate on the Chesapeake Bay and develop a strategy for adapting natural resource programs and public infrastructure to the impacts of a changing climate on water quality and living resources of the Chesapeake Bay watershed." Section 601 of the EO directs the Secretaries of Commerce and Interior to organize and conduct research and scientific assessments to evaluate the impacts of climate change in future years and to support development of a strategy to adapt to climate change impacts on the Chesapeake Bay watershed. This report provides an overview of some of the anticipated impacts of climate change on Bay resources, and examples of existing federal programs that could collaborate on adaptive responses. The report is divided into six major parts: Executive Summary, Background, Overview of Impacts, Adaptive Actions, Technical Needs, and Climate Change Strategies.

This report recommends a range of technical, management and adaptation strategies across multiple timelines. It also recommends a process that continually builds upon the best available scientific information because so much of our understanding of climate change and our ability to project impacts is still developing. Many of the recommended strategies should be implemented in the near term, and all adaptation efforts should be reviewed and modified as new information becomes available. The recommendations in this report are based on a review of numerous studies (see Part VII) on the impacts of climate change on coastal zones and watersheds and recent management reports on the mid-Atlantic region (including in the Chesapeake Bay). Although there is still much uncertainty surrounding climate change projections and specific impacts, available information is sufficient to begin adapting to and mitigating the most likely impact scenarios and to raise awareness among policy makers and the public. In summary, the potential significance of climate impacts to the Bay demands taking both adaptive and mitigative action now, with strategies designed to be regularly adjusted as our understanding of climate change impacts on the Bay continues to evolve.

The two key recommendations in this report are to:

1. Coordinate climate change adaptation and management activities throughout the watershed; and
2. Implement climate change adaptation on federal lands and within federal agencies and programs.

A complete presentation of these recommendations is provided in Part VI of this report.

II. Background

Climate change adds a new level of complexity to natural resource manager and policy decision-maker efforts to restore and protect the Chesapeake Bay and its fish, wildlife, and native plant populations. The Chesapeake Bay ecosystem is already degraded due to a long history of land clearance and development, fertilizer use, and human population increases which have resulted in reduced water quality, habitat loss, lower levels of dissolved oxygen, high turbidity, and disturbed biological communities (U.S. Geological Survey, 2007). Climate change will have additional impacts on water quality and quantity, public health, the sustainability of aquatic freshwater and marine and terrestrial living resources, as well as the quality of life and economic well-being of the watershed's 17 million residents. Managing the Chesapeake Bay and its watershed to accommodate climate change impacts will be further complicated by future population growth and associated land use decisions throughout the watershed. This is particularly true for the region's coastal areas due to the impacts of sea-level rise. Therefore, the Chesapeake Bay Program and its partners should recognize that the Bay will experience significant changes due to climatic variability, and history should not be used as the only guide for establishing future restoration targets.

The Earth's climate is changing in part due to human activities that have released unprecedented levels of heat-trapping greenhouse gases into the atmosphere in a relatively short period of time. Mitigation strategies, like those in proposed federal cap and trade legislation, seek to reduce the amount of emissions released in an effort to minimize the overall magnitude of global climate change. However, according to the Intergovernmental Panel on Climate Change (IPCC), regardless of mitigation actions taken to limit emissions, the level of greenhouse gases already in our atmosphere commit the Earth to significant levels of climate change (Teng et al., 2006). Therefore the federal government has a vested interest in

developing adaptation strategies to plan for and respond to those changes. While we recognize that there are existing uncertainties surrounding climate change projections, we do know that the severity of the impacts, particularly by mid- and late-century, is very sensitive to the amount of greenhouse gases emitted globally over the coming decades. While our report and recommendations focus primarily on adaptation strategies, we recognize that immediate mitigation actions taken by federal and state partners may be the most effective in limiting the extent of climate change. Many of these actions are already underway through state energy plans, regional greenhouse gas emissions reporting and reduction programs (eg, Regional Greenhouse Gas Reduction Initiative) or are currently being considered for federal legislation (eg, Waxman Markey Bill: American Clean Energy and Security Act of 2009). In addition to tackling the key issue of emissions regarding climate change, these activities often provide a means for funding adaptation measures.

According to a recent synthesis by the Chesapeake Bay Program's Scientific and Technical Advisory Committee (STAC) (Pyke et al., 2008) and by the Maryland Climate Change Commission (Boesch, 2008), by the year 2100 regional warming is projected to be 4^0 to 11^0F above the historical average, relative sea level is projected to rise by 2-5 feet (60-150 cm), mean winter and spring precipitations are likely to increase (potentially up to 10%), and storm intensity may increase. Because of higher initial sea levels, even the same strength of storms will produce more coastal inundation. Over the last century, sea level in the Chesapeake Bay has risen approximately 1 foot (30 cm). Tide gauge measurements throughout the Bay show a steady increase in sea levels due to thermal expansion of the oceans, melting glaciers and ice sheets, and regional subsidence. Given the low relief topography bordering most of the Bay, sea-level rise and storm surge are serious threats to coastal communities and habitats.

Hurricane Isabel (2003) provides a compelling example of the destructive nature of coastal storms. This storm made landfall in North Carolina as a category 2 storm and resulted in more than $3 billion in damages and 50 deaths either through direct or indirect storm impacts across eight Atlantic states from North Carolina to New York (Bevin and Cobb, 2003).

Despite existing uncertainties, Virginia and Maryland have already developed climate action plans (Governor's Commission on Climate Change, 2008; Maryland Commission on Climate Change, 2008), while Delaware, Washington, D.C. and Pennsylvania are currently developing similar plans. Maryland, in particular, has adopted innovative strategies to adapt to the impacts of increasing sea-level rise. However, even though states such as Maryland and Virginia have identified their needs and recommended actions, lack of funding, political will, existing institutional frameworks, and uncertainties associated with climate change projections challenge their ability to effectively implement the full list of strategies. Given these challenges, this report recommends increased Federal and regional collaboration to address climate change impact issues, and provides recommendations to spur adaptive action in the Bay, addressing many of the existing barriers to widespread adaptation implementation.

III. Overview of Impacts

A summary of potential climate change impacts to the Bay ecosystem and watershed is provided in Table 1. This list is not meant to be comprehensive or exhaustive but does provide an overall perspective of the scope and variety of impacts that should be considered in designing adaptive strategies to climate change.

The following sections discuss specific impacts on the Chesapeake Bay and its watershed resulting from sea-level rise, increases in temperature, acidity, and salinity, and changing rainfall patterns and increases in rainfall intensity. The final section on impacts focuses on public infrastructure and human health. Broad recommendations related to the federal role in adapting to climate change are discussed in Part VI of this document. It is important to keep in mind that this overview represents expected impacts from projected warming scenarios based on current knowledge. The magnitude of impacts will largely depend upon future global carbon dioxide emissions, and could be either mitigated (reduced) through global reduction strategies or enhanced by the lack of mitigation actions.

A. Rising sea level and storm surge in the Chesapeake Bay

The probability of more rapid rates of sea-level rise in the future is one of the greatest threats to the Bay and its aquatic and coastal ecosystems. It is well established that the mean rate of relative sea-level rise, accounting for land subsidence, in the Chesapeake region exceeds the rate of global sea-level rise. Regional land subsidence is caused by post-glacial rebound over the past ~ 10,000 years (Cronin et al., 2007, Larsen and Clark, 2006). In local areas, compaction of subsurface layers may also contribute to land subsidence. Although the mean long-term rate of sea-level rise has been about 1 foot (30 cm) over the past century, relative sea-level rise can vary throughout the Bay region due to different rates of land subsidence. Rates of relative sea-level rise as determined from long-term tide station records vary across the region from about 1 foot per century in the northern and central Bay to about 1.5 feet per century along the Virginia's lower southeastern shore (CCSP 2009).

Wu et al., (2009) estimated a projected total future sea-level rise of between 1.7 and 2.0 feet (528-599 mm) by the year 2100 at Annapolis, Maryland using two IPCC (Intergovernmental Panel on Climate Change) greenhouse gas emission scenarios, A2 and B2 (IPCC, 2000). But this study did not take into account several important factors that suggest future rates might be higher than previously expected. For example, new studies suggest that future rates of sea-level rise given by the widely cited IPCC 2007 4th Assessment Report (AR4), similar to those used by Wu et al. (2009), are considered underestimates because they do not take into account mass balance changes in the Greenland and Antarctic ice sheets (e.g. Shepherd and Wingham, 2007). The AR4 estimates also do not account for the regional oceanographic effects due to changes in Atlantic Meridional Overturning Circulation (Hu and Meehl, 2009, Yin et al., 2009), which Yin et al. suggest could significantly increase the sea level rise in the Chesapeake Bay region, beyond that caused by global increases and regional subsidence. In addition, paleo-sea level records show mean global sea-level rise rates can exceed approximately 0.33 in/yr (8-10 mm/yr, or 3 feet/century) during periods of climatic warming and rapid ice sheet melting (Cronin et al., 2007). These values are more than twice the historical rate and should be considered within the range of potential future scenarios over the next 1-2 centuries.

According to the National Wildlife Federation (2008), by 2100 sea-level rise will lead to tremendous change along the Chesapeake Bay. They project that the region will lose more than 167,000 acres of undeveloped upland area, 161,000 acres of brackish marsh, 69% of our estuarine beaches, 58% of our ocean beaches, and more than 50% of our tidal marshes. These areas will be replaced by more than 266,000 acres of open water and 50,000 acres of saltmarsh.

Inundation:

Inundation directly threatens coastal habitats and communities. For example, Virginia's Hampton Roads region is considered to be one of our nation's populated centers most at risk from sea level and related storm damage. Other populated areas such as Alexandria, Virginia have already experienced flooding damage from water inundation and are at greater risk due to sea-level rise (Virginia's Commission on Climate Change, 2008). The amount of land inundated by a given sea-level rise is a complex function of elevation, shoreline geology, land use, wetland ecology, and the rate of sea-level rise (Pyke et al., 2008). Coastal development confines the inland migration of species and fragile coastal habitats. For portions of the southern and eastern Chesapeake Bay especially, where there are many small marsh islands and vast areas of low-lying land with very little vertical slope, gradual inundation of the land by the combination of sea-level rise and land subsidence is already an issue of great concern. These low marshes and islands are especially vulnerable to flooding during nor'easters and tropical storms, and are currently exhibiting rapid shoreline erosion (Figure 1). Since the 1930s, more than over 8,000 acres (3,000 hectares), or 12 square miles, of marsh at Blackwater National Wildlife Refuge has been lost at a rate of 150 acres (60 hectares) per year. Causes of this marsh loss include sea-level rise, erosion, subsidence, salt water intrusion, and invasive species (such as the recently extirpated nutria). Similar losses have occurred, and continue to occur, throughout the Bay region. Strategies to either abandon or protect these high risk areas must soon be developed (U.S. Fish and Wildlife Service 2008). In addition, farms located in low-lying or coastal areas will experience severe flooding and saltwater intrusion.